

METHOD OF INJECTING/EXTRACTING CONTROL CELLS IN AN  
ASYNCHRONOUS TRANSFER MODE (ATM) NETWORK

BACKGROUND OF THE INVENTION

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10 1. Technical Field:

The invention relates generally to Asynchronous Transfer Mode (ATM) networks wherein a source ATM device and a destination ATM device are connected by multiple intermediary network switching nodes, and relates in particular to a method for injecting control cells such as Operation And Maintenance (OAM) cells into the source-to-destination connection at an injection switching node and extracting the control cells from the connection at an extraction switching node.

15 20 25 2. Description of the Related Art:

A connection is established in an ATM network from a source ATM device to a destination ATM device by multiple intermediary switching nodes. Incoming cells into a switching node are automatically routed to the next switching node of the connection. To this end, each cell includes an ATM header and a payload. An ATM protocol engine in the switching node identifies an incoming ATM cell utilizing a lookup table.

30 Upon a determination that an incoming cell is a valid cell ("valid" meaning belonging to an existing connection), the protocol engine performs traffic management functions related to traffic policing, congestion management, priority management, etc., and queues the cell in an appropriate queue. A scheduler  
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utilizes priority-based scheduling procedures to select queues from which cells are transmitted. Upon selection by the scheduler, the cells are dequeued from their respective queues.

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Prior to transmission of the cell from the switching node, the protocol engine adds routing labels to the cell including a switch routing label (SRL) and a protocol engine correlator (PEC). A cell formatted in accordance with such labeling by the protocol engine is processed within the switching node and will be referred to hereafter as a "labeled cell".

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The SRL contains either the identity of the destination blade explicitly, or a pointer to a translation table located in the switching device that contains the explicit destination blade identity. The PEC is a pointer utilized by the protocol engine of an output adapter of the switching node to identify the connection to which the cell belongs. The protocol engine in the output adapter receives the cell from a switching interface within the switching node. Similar to the input protocol engine, the processing performed by the output protocol engine on the cell includes: identifying the incoming cell by performing a lookup on the appended protocol engine correlator; performing traffic management functions; queueing the cell in the appropriate queues; dequeuing the cell in accordance with a scheduler. In addition, the output protocol engine removes the appended labels, swaps the ATM label, and transmits the cell on the connection to the appropriate destination ATM port(s).

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Conventionally, transmitting control cells, such as  
Operation And Maintenance (OAM) cells, from an ATM  
switching node to another ATM switching node of the  
connection, requires transmission of control messages  
between the two switching nodes using specific hardware  
resources such a microprocessor dedicated to such a task  
in each switching node. However, such a solution is  
inefficient both in terms of cost and overhead devices  
inasmuch as it requires incorporation of microprocessors  
on the adapter cards of the switching nodes in addition  
to the Application Specific Integrated Circuit (ASIC)  
modules that are utilized to route non-control ATM cells.

## SUMMARY OF THE INVENTION

A method and system for injecting a control cell into an Asynchronous Transfer Mode (ATM) data connection between a source ATM device and a destination ATM device are disclosed herein. A control cell is injected into the connection by the control point of an injection switching node. The control cell injection method includes generating a control cell composed of a payload and an ATM header containing the input VP/VC of the connection in order to constitute an ATM cell. A switch routing label (SRL) and a protocol engine correlator (PEC) are added to the control cell to label the control cell. An injection flag is set in the labeled control cell for indicating to the protocol engine of the control point that the cell is a control cell to be injected into the connection.

A second aspect of the invention relates to extracting a control cell from the ATM data connection. The method includes determining within an extraction switching node, whether an incoming cell includes an extraction condition. If the incoming cell includes an extraction condition, a control flag is set in the control block of the incoming cell that indicates that it is a control cell to be extracted. A switch routing label corresponding to the control point (CP SRL) and a reserved static protocol engine correlator (SPEC) are added to the control cell before it is transmitted to the switch of the extraction switching node, such that the cell is extracted on the downside of the switching node.

All objects, features, and advantages of the present invention will become apparent in the following detailed written description.

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BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages  
of the invention will be better understood by reading the  
5 following more particular description of the invention in  
conjunction with the accompanying drawings wherein:

10           **Fig. 1** illustrates an ATM network in which a  
preferred embodiment of the present invention is  
applicable;

15           **Fig. 2** is a block diagram depicting a switching node  
in which a preferred embodiment of the present invention  
is applicable;

20           **Fig. 3** illustrates a cell injection system and a  
cell extraction system in accordance with a preferred  
embodiment of the present invention;

25           **Fig. 4** is a block diagram depicting a system for  
injecting a control cell within an injection switching  
node in accordance with a preferred embodiment of the  
present invention;

30           **Fig. 5A** and **5B** are block diagrams illustrating a  
system for processing and extracting a control cell  
within an extraction switching node in accordance with a  
preferred embodiment of the present invention; and

35           **Fig. 6** is a flow diagram depicting the sequential  
steps of the process implemented for processing a  
previously injected control cell in accordance with a  
preferred embodiment of the present invention

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference now to the figures wherein like reference numerals refer to like and corresponding parts throughout, and in particular with reference to **Fig. 1** shows an example of an ATM network **10** implementing the system according to the invention, and comprising four switching nodes **12**, **14**, **16** and **18** being respectively connected to local consoles **20**, **22**, **24** and **26**. Each switching node is composed of a Control Point (CP) blade such as CP blades **28** of switching node **12**, a plurality of adapter blades such as adapter blade **30** in node **10**, which provide the physical attachments to network devices such as the other switching nodes or the user workstations and a switch fabric providing cell switching between its ports on which are attached the adapter blades. The local console attached to the CP blade in each node is used for the network and control management.

It is assumed that a connection is established between a source ATM device attached to switching node **12** and a destination ATM device attached to switching node **18** through intermediary switching nodes **14** and **16**. According to the principles of the invention, control cells can be injected into this connection by control point **28** of node **12** and can be extracted by control point **29** of node **18**, utilizing extant hardware resources included in each of said nodes. It must be noted that the control cells could also be injected by a control point of any intermediary switching node such as node **14**, and could be extracted by any subsequent intermediary switching node such as node **16**.

With reference now to **Fig. 2**, there is illustrated a block diagram depicting a switching node in which a preferred embodiment of the present invention is applicable. Specifically, **Fig. 2** shows the internal structure of each switching node, each adapter blade 30, and each CP blade 28. As depicted in **Fig. 2**, the adapter blades and CP blades share the same flow structure. One of the two ASIC modules used in each blade is a Common ATM Data mover (CAD) module 32 which performs functions related to the data flow. The other ASIC device is a Common ATM Processor (CAP) module 34 that performs the necessary ATM processing. As illustrated in **Fig. 2**, each CAD 34 is connected to a switch device 36.

Each of CAD modules 34 and CAP modules 32 is split into two parts, an UP side for the receive flow and a DN side for the transmit flow. The CAD UP side receives data from transmitted from physical links and stores them in a data storage. For each cell received, CAD UP exchanges information such as VP, VC and cell buffer ID with the CAP UP for cell processing. The CAP UP sends back information needed to forward the cell through switch 36 via the CAD UP. This cell forwarding information is found in a control storage delivered by the CAP UP side. Note that switch 36 connects blades UP to blades DOWN and forwards cells from an input port to an output port.

The CAD DN side receives data from switch 36 and stores it in a data storage. For each cell received, the CAD DN side exchanges information such as Protocol Engine Correlator (PEC) and cell buffer ID with the CAP DN for cell processing. The CAP DN side returns information

needed to forward the cell to the correct destination port and ATM connection via the CAD DN side. CP blades includes the same structure as adapter blades, wherein the control point is an ATM device of the ATM network.

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Turning now to **Fig. 3**, there is illustrated a cell injection system and a cell extraction system in accordance with a preferred embodiment of the present invention. As shown in **Fig. 3**, an ATM connection **40-40'** is setup from a first switching node **41** called the injection node to a second switching node **43** called the extraction node through an ATM network **10**. The injection of control cells into ATM connection **40-40'** is performed by a control point **45** of injection node **41** while extraction of the control cells is performed near a control point **47** of extraction node **43**.

With reference now to **Fig. 4**, there is illustrated a block of a control cell injection system in accordance with a preferred embodiment of the present invention. The control cell injection system depicted in **Fig. 4** is utilized for injecting an OAM control cell **59** in a particular ATM connection at an injection switching node **49**. The particular ATM connection is characterized within injection switching node **49** by the input port address in the switching node, the input ATM label (VP-VC in), the output port in the switching node, and the output ATM label (VP-VC out).

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When a non-control ATM cell belonging to the ATM connection is received by an input blade of injection switching node **49**, an input protocol engine **51** identifies the incoming cell using a lookup table **48** with the input

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port and input ATM label designation of the cell. The lookup returns relevant traffic parameters and routing parameters. Such routing parameters comprise a Switch Routing Label (SRL) processed by a switch device **44** of injection switching node **49** to route the cell to an appropriate output blade and a Protocol Engine Correlator (PEC) that is utilized by an output protocol engine **53** of the designated output blade to identify the cell received from switch device **44**.

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To inject OAM cell **59** (or any type of other control cells known to the person skilled in the art such as Resource Management (RM) cells) on the ATM connection, a CP **42** transmits OAM cell **59** and labels OAM cell **59** with the following: an input VPI-VCI of the designated ATM connection; the routing labels of the defined connection (SRL and PEC); the Payload Type Indicator (PTI) field of the ATM header defining the cell as an OAM cell (respectively RM cell); and a flag indicating the cell is an injected cell.

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In response to receiving input OAM control cell **59** generated and characterized by CP **42**, input protocol engine **51** (located within the control point blade) reads the injection flag and bypasses ATM label lookup **48** in response thereto. The injection flag is encoded into and read from the header of the labeled control cell. After bypassing ATM lookup **48**, protocol engine **51** performs an enqueue function **55** in which the labeled control cell is assigned into queues **50** and a dequeue function **57** is performed. Then, the injection flag is again read by protocol engine **51** to bypass the routing label appending function **61**. OAM cell **59** is thus directly transferred to

a XMIT unit 52 for transmission to switch 44. Prior to transmitting OAM cell 59 to switch 44 protocol engine 51 removes the injection flag from the header of OAM cell 59.

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Upon receipt by switch 44, OAM cell 59 has exactly the same processing information in its header as a conventional non-control ATM cell within the ATM connection, except that this information (SRL, PEC) has been assigned by control point 42 of injection node 49. After being switched through the switch fabric of switch device 44, the data flow process utilized to process the injected OAM cell is the same as that utilized for non-control ATM traffic cells. As shown in Fig 4, upon transmission from an output port of protocol engine 53 to the ATM network, OAM cell 59 includes the OAM payload and the swapped label (ATMH OAM).

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Turning now to Fig. 5A and 5B, block diagrams are utilized to illustrate a control cell processing system in accordance with a preferred embodiment of the present invention. During initialization of a switching node 69, a CP (not depicted) within switching node 69 determines and defines multiple static routes from all input ports of switching node 69 that lead to the control point. In doing so, the CP defines two static parameters for all input blades of switching node 69 including the following: the SRL (referred to hereinafter as CP\_SRL) that corresponds to the output blade to which the control point is attached (this parameter is common to all blades), and a blade identifier (referred to hereinafter as B\_id), that is, in accordance with a preferred

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embodiment of the invention, the encoded value of the blade (this parameter is blade-specific).

The blade identifier will be used by a protocol engine 71 of an input blade to generate a particular PEC that will be denominated hereinafter as a Static PEC (SPEC). The SPEC is encoded with the identity of the input blade (*B\_id*) and the identity of an input port in the input blade. For example, a possible SPEC encoding may take the form: SPEC = b'00 0000 00PP BBBB' where BBBB = *B\_Id* and PP = *encode\_port*. Such encoding permits the CP of switching node 69 to account for possible intra-node routes formed from 16 blades, wherein each blade includes 4 ports, and that standard PECs are 14 bits wide. One skilled in the art will recognize that any alternate encoding may be chosen without departing from the scope of the invention.

The CP then reads a PEC table of the output blade to which the CP is attached to identify table entries that corresponding to the SPECs utilized in switching node 69. In the previous SPEC example, the CP designates 64 entries in the PEC table corresponding to the 64 static routes from any of the 64 ports of switching node 69 to control point 82. Each of the SPEC entries specifies that the cell received with the particular PEC has been extracted. This extraction information will be utilized, as shown hereafter by an output protocol engine 81 of CP blade 82, to modify its conventional ATM traffic cell processing when handling an extracted cell. It is important to note that the SPECs can not be utilized by ATM connections within CP blade 82 (the SPECs are

dedicated and statically allocated to the extraction process).

When an ATM cell 79 is received at an input port in an input adapter of extraction switching node 69, protocol engine 71 determines whether cell 79 is to be extracted. In making such a determination, various extraction conditions may be used, the simplest being a per connection flag indicating that all received OAM cells of the connection are to be extracted. Protocol engine 71 sets a control flag in the control header of cell 79 to be extracted and performs its regular process from MPX unit 76 to XMIT unit 72. However, instead of appending the labels conventionally utilized for ATM user traffic as found in the connection control blocks, protocol engine 71 appends a SRL corresponding to the switch output port to which the control point is connected (CP\_SRL) and further appends a reserved Static Protocol Engine Correlator (SPEC) using the Blade identifier B\_Id information to the extracted OAM cell 79.

In contrast to the dynamic process by which the conventional connections are established, CP 82 establishes static paths during initialization of switching node 69. Thus, CP 82 defines for each input adapter, a register that contains a designated SRL (CP\_SRL) which provides a path to reach CP 82. In addition, CP 82 designates a particular SPEC identifying the input adapter. When cell 79 is transferred by XMIT unit 72 to switch 74, it includes the CP\_SRL and the SPEC as a header for the OAM payload as illustrated in Fig. 5A.

Switch 74 routes labeled cell 79 to the CP adapter as illustrated in Fig. 5B. Protocol engine 81 performs the routing label (PEC) lookup function 84, resulting in a determination by protocol engine 81 that cell 79 has been extracted to CP 82 (this extraction information is written by CP 82 in the entries of lookup table 84 that correspond to the reserved labels used to extract the cells). Protocol engine 81 then flags cell 79 by setting an extraction flag in the cell header. After queuing and dequeuing by means of queues 80, the extraction flag is used by protocol engine 81 to bypass the remove routing label/ATM label swap function and deliver cell 79 directly to XMIT unit 88 so that cell 79 is received by CP 82 after DMPX unit 86 containing only the incoming ATM label (input VP/VC) and the source and input adapter identifications encoded in the SPEC. This labeling allows CP 82 to identify the connection to which the received extracted cell belongs.

With reference now to Fig 6, there is depicted a flow diagram representing the sequential steps of the process implemented for processing a previously injected control cell in accordance with a preferred embodiment of the present invention. When a cell has been identified (step 70) by the protocol engine of the input adapter (if not identified the cell is discarded), it is checked to determine whether or not the cell is to be extracted as a control cell (step 72). If not, the switch routing label (SRL) and the protocol engine correlator (PEC) of the connection to which the cell belongs are appended to the cell as for all traffic cells (step 74). If the extraction condition exists, a special switch routing label to the control point of the switching node (CP SRL)

and a reserved static protocol engine correlator (SPEC) are appended to the cell (step 76).

In any case, the cell is then routed by the switch of the switching node (step 78) and in the output blade, a PEC lookup is performed (step 80) whose result indicates whether or not the cell contains an extraction flag (step 82). If not, the cell is processed regularly: a label swap is performed (step 84) and the routing labels (SRL and PEC) are removed (step 86) prior to cell transmission (step 88). Otherwise, the cell is transmitted to the control point of the switching node (step 90) with its header including CP SRL and SPEC (encoding the source port and the source blade) which have not been removed as in a normal cell and are used by the control point to identify the connection from which the cell was extracted.

While the invention has been particularly shown and described with reference to a preferred embodiment, it will be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the invention.